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AUTHOR Truex, Ronald T.
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ABSTRACT

This report describes program that was designed to provide non-academic disaffected students as well as college-bound high school students with a meaningful and positive educational experience in science in order to bridge the gap between science and the citizen in a technological world. The program, designed as a full year elective course, involves the students in activities and projects that reflect concerns regarding current issues in science. The major unit of study in this course are matter and energy; meteorology; astronomy; atomic energy; space exploration; population growth; alternate energy sources; health hazards of drugs and smoking; and air, water, and noise pollution. Because of the interdisciplinary theme of the course of study, this program is designed to improve the entire school program by incorporating concepts and skills from other academic areas. These areas include social studies, math, industrial arts, and English. Included are the following: (1) an overview of the program; (2) a literature review; (3) program description; (4) sample activities; and (5) the design and results of the program evaluation. (KR)

TOWNSHIP OF OCEAN SCHOOL DISTRICT
CONTEMPORARY SCIENCE

PROGRAM DESCRIPTION
SEPTEMBER, 1989

Written By:
Ronald T. Truex

New Jersey Governor's Teacher Grant Program - 1987
New Jersey State Department of Education

CONTEMPORARY SCIENCE

Developed by:

Ronald Truex

Township of Ocean School District
163 Monmouth Road
Oakhurst, New Jersey 07755

1987 Governor's Teacher Grant
New Jersey Department of Education

Saul Cooperman, Commissioner
Thomas H. Kean, Governor

STATE OF NEW JERSEY
DEPARTMENT OF EDUCATION
CN 500
TRENTON, N.J. 08625-0500

OFFICE OF THE COMMISSIONER

Commissioner's Statement

Recognizing teachers as invaluable resources for school improvement, Governor Thomas H. Kean established the Governor's Teacher Grant Program in 1985. Under this program, grants awarded to selected teachers enable them to prepare materials that support their proven instructional practices and to make these available to educators throughout the state.

Now, in this fourth year of the program, a second edition of teacher-developed materials is being disseminated. Through this sharing, we give recognition to teachers as a rich source of ideas and effective methods. We are indeed grateful to those dedicated teachers selected as Governor's Teacher Grant recipients whose efforts ultimately benefit New Jersey students.

Saul Cooperman
Commissioner

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I. PROGRAM OVERVIEW

CONTEMPORARY SCIENCE

Science and technology, powerful forces in contemporary American society and throughout the world have generated exalted hopes, terrible fears, and critical public issues. To understand the workings of the modern world - to be a truly educated person in our times - requires an understanding of science and technology in a social context.

1. Purpose

"Contemporary Science" is a program designed to provide non-academic disaffected as well as college-bound high school students with a meaningful and positive educational experience in science in order to bridge the gap between science and the citizen in our technological world.

2. Overview of Course

The Program -The program, which is a full year elective course offered on a five day per week basis to all students in eleventh and twelfth grades (can also be offered in ninth and tenth grades), involves the students in activities and projects that reflect concerns regarding current issues in science. The major units of study in this course are: Research Skills, Matter and Energy, Meteorology, Astronomy, Atomic Energy, Space Exploration, Population Growth, Alternative Energy Resources, Health Hazards of Drugs, Alcohol and Smoking, and Air, Water and Noise Pollution. These units have been updated by the instructor on an almost annual basis during the past 18 years to reflect the most current information and events.

The Student - This project is unique because it builds upon student experiences and previous education. Academic skills from lower grades are refined and reinforced. A variety of instructional techniques and tools are utilized throughout the program to enhance student learning. Students will actively participate in laboratory experiences, independent study projects, field trips, and the presentation of oral and written reports that require extensive library research.

The School - Ocean Township High School serves a suburban middle to upper-middle residential community which is located in Monmouth County. The school includes grades nine through twelve with a population of 1260 students. Approximately 82% of the graduating students attend two or four year colleges. There are 124 professional staff members at Ocean Township High School.

Cost and Materials - "Contemporary Science" is a cost effective program for the district because the facilities and materials required for Biology, Chemistry and Physics courses are utilized for program activities.

Program materials available are a 100 page Teacher Curriculum Guide which includes four evaluation instruments and a 358 page Student Enrichment Materials manual. For further questions and information please contact:

Office of Special Projects
Township of Ocean School District
Oakhurst, NJ 07755
(201) 531-5620

II. REVIEW OF THE LITERATURE

In an attempt to meet the demand for scientists and engineers in our society, science courses at the secondary level were developed to teach the facts and theories of science. This approach to science education is reflected in many of the large-scale curriculum projects which were developed during the sixties and seventies. These projects helped to meet the demand for scientists, but they accomplished their goal at a serious expense. Although an elite group of students were able to master the concepts and theories of pure science, the majority of students found the study of science to be too difficult. As a result, there was little interest or motivation to study science (Fensham, 1986).

Because of the decline of student interest in science, educators have recognized the need for an alternative approach to science education (Jones and Zucker, 1986). If students come to understand science as merely a list of facts and theories, both the students and our society will be losers. Science should be viewed as a dynamic discipline where social, political and personal forces have significant roles.

The impetus for the design and development of this type of science program has been fostered by the constant change in our society. Science educators have been urged to consider such changing needs in their teaching. As students progress through school, their experiences will change and they will encounter various situations and problems to which science can contribute. Teachers should use the relevant parts of science to bring to their classrooms the type of science education that will enable students to understand their world more effectively. This type of science education should also enable students to believe that science and technology are great human inventions in which they participate for the well-being of their own society (Fensham, 1986).

Likewise, the social relevance of science indicates the need for all citizens to understand the process and application of science. To accomplish this task, the most significant influence upon science teaching at all levels should be current societal problems and issues (Koballa, 1984). Basic scientific research is translated into applied technology at a rapid rate. This situation places tremendous demands on those citizens who do not have a basic grasp of science.

These may be the same individuals who are called upon as voters or workers to respond to critical issues such as genetic engineering, toxic waste management, or the use of robotics. From such examples, there is little doubt that science education will play a major role in preparing students for the future. It has been suggested that students be exposed to those basic scientific principles which will enable them to understand issues related to human survival (Roy, 1986). One such issue is world energy. This issue will continue to be a key factor to world stability, and it must be perceived holistically by students.

Because of its central position in supporting the technologically advanced economy of the future, scientific literacy may be at the core of general literacy (Kormondy, 1985). Reflecting on this role of science education, it has been recommended that new instructional material in science should prepare students for effective citizenship in a democratic society. This recommendation has been interpreted as preparing students to comprehend the components of a changing society that depends heavily on science and technology (McInerney, 1986).

While emphasizing the social relevance of science, there is also a need for relating science to technological advancements (Yager, 1987). The science curriculum projects of the past neglected the use of technology for learning scientific concepts and theories. The use of technology as a focus for science instruction provides concrete examples of the application of science. Such examples may serve to increase motivation. This approach can revitalize the study of science and it may stimulate a greater number of students to learn pure science.

The need for the new emphasis and revitalized approach to science education has been recognized by various organizations and supported by formal studies. The Horizons Committee of the National Science Teachers Association has formulated several propositions aimed at a new approach for science education in the twenty-first century (Watson, 1983). These propositions indicate that a balanced education must integrate schooling in science, language, social studies, mathematics, and humanities. The committee also states that education in technological issues provides options for decision making, career planning, and daily life. As a result, science teachers have the obligation to communicate not only the conclusions of science, but also its social implications.

The committee suggests that when science education provides students with experiences they can relate to, it forms the basis of a lifetime of problem seeking and solving. Thus, an essential goal of science education is to encourage students to develop into independent learners who are able to acquire information from many sources, to weigh alternatives and to reach defensible conclusions.

An intensive investigation of programs at the secondary level revealed numerous concerns about the state of science education (Harms, 1981). Instructional goals related to the everyday application of science, to career planning, and to scientific literacy for societal decision making have been ignored. Such goals for the majority of students are as important as the goal of preparing a minority of students for more advanced coursework in science.

A study of exemplary science programs (Pennick, 1986) reveals an application of many of these instructional strategies. Teachers of such programs recognize the need for students who understand the utility of science. Students need to perceive science as a way of investigating and evaluating solutions to problems and new ideas. Teachers of exemplary programs also enable students to see science in relation to a variety of careers, not just those traditional careers of medicine and engineering.

Considering all of the recommendations for an alternative approach to science education, it has been recognized that it is unrealistic to expect that science teachers can provide students with all of the information that they will need in the future (Harms, 1981). Thus it is important that students be provided with the fundamental skills and attitudes that will prepare them for acquiring information and knowledge in their future lives.

The previous discussion has placed "Contemporary Science" within the perspective of recent recommendations for alternative approaches to the study of science. Rather than studying scientific principles in isolation, this approach emphasizes the investigation of contemporary problems in science, the development of decision making skills, the integration of career awareness, and the fostering of positive attitudes towards science and technology.

III. DESCRIPTION OF THE PROGRAM

Instructional Objectives

As a result of the integration of numerous aspects of the natural and physical sciences as they relate to a student's understanding of the world, the following outcomes are expected from participants in the "Contemporary Science" program:

1 - Student scientific curiosity and interest will be stimulated

2 - Students will develop positive attitudes and an appreciation of science/technology as worthwhile human endeavors

3 - Students will understand the critical importance of ethical questions about the uses of science/technology in society

4 - Students will be provided with access to scientific and technological information that enables them to make intelligent decisions and judgements about issues in science such as nuclear energy, pollution, population problems, space exploration and health

5 - Students will improve scientific literacy through involvement in activities that reinforce basic skills, such as library research, mathematics, and oral/written communication

6 - Students will engage in independent study of science/technology topics in order to allow them to pursue their own interests and concerns while addressing individual differences in learning styles

7 - Students will develop an understanding of the numerous career opportunities in science and technology

Methods of Instruction

It is recommended that the following variety of approaches be utilized in the presentation of the "Contemporary Science" Program.

1 - NOTEBOOK - Require students to keep a complete and updated notebook throughout the course

2 - ENRICHMENT MATERIALS - Utilization of varied worksheets and study guides as appropriate for specific units studied

3 - VISUAL AIDS - Extensive use of variable types of visual aids including: films, videotapes, filmstrips, charts, transparencies, diagrams, and computer programs

4 - CURRENT SCIENCE RESOURCES - Encourage the use of newspapers, magazines, books, and television science programs to obtain updated scientific information

5 - INDIVIDUAL/CLASS PROJECTS - Utilize oral reports, group projects, student demonstrations and class discussions

6 - LABORATORY INVESTIGATIONS - Numerous laboratory investigations can be incorporated within each unit of study where applicable

7 - COMMUNITY RESOURCES - Invite guest speakers from science/technology fields to present information on career opportunities, qualifications and impact on their respective fields on society

8 - FIELD TRIPS - Schedule field trips during the course where appropriate

9 - INTERDISCIPLINARY APPLICATIONS - Emphasize the interdisciplinary nature of science by working with the Math, English, Social Studies, Industrial Arts and Health departments in incorporating student project and research work into their programs

Instructional Materials and Activities

The physical resources required for the implementation of the "Contemporary Science" program are minimal. The laboratory materials and equipment already present in most high school science departments will suffice. In addition, access to duplication equipment, a computer and audio-visual facilities would be necessary.

The program components available for schools interested in instituting the "Contemporary Science" program are a 100 page Teacher Curriculum Guide which contains twelve units of study. Each unit of study includes the following information: Background Information, Unit Objectives, Content Outline, Activities, Audio-Visual Aids and References.

In addition the following four evaluation instruments are included: a 100 question Pre/Post Test, a 50 question attitudinal survey on the seventeen major issues studied, a student evaluation of the course and a parental evaluation of the course.

Also included is a 358 page Student Enrichment Materials Manual which contains detailed student activities to be used in conjunction with the twelve units of study. Each activity includes the following: Title, Purpose, Objectives, Materials, Procedure, Background Information (when needed) and Charts/Graphics (for preparation of transparencies or student handouts).

Suggested Methods of Evaluation

1. QUIZZES - Periodic quizzes provide feedback for both teacher and student regarding the level of understanding. These evaluations can be short answer or multiple choice that stress mastery of basic concepts.

2. TESTS - Major unit tests should be administered at the conclusion of a unit. These tests should be of the short answer, essay or multiple choice variety. Emphasis should be on concepts rather than rote memory. Tests should be designed to develop higher order thinking skills such as analysis and evaluation. Open notebook tests encourage students to take accurate notes and to apply concepts and information.

3. INDEPENDENT RESEARCH REPORTS - A major course requirement will be the use of library research skills for the completion of scientific research each marking period. These reports are included in activities that are components of individual units.

4. ORAL REPORTS - The presentation of library research reports enhances the development of communication skills. This technique allows students to share information about topics of scientific interest.

5. NOTEBOOK - Notetaking is a vital part of the program since a variety of instructional resources are utilized in the absence of a formal text. Accuracy and organization of notebooks will be utilized as a measure of evaluation.

6. ATTENDANCE - Since the program does not have a book it is vital that the student be present in order to keep abreast of the new information presented daily. When a student is absent, grade deductions will be made. The student can make these deductions up by completing a short written report on a current science event from a newspaper or magazine.

7. CLASS PARTICIPATION - Student involvement in small group and class discussion is an integral component of the course. It is vital that students become actively involved in expressing and debating personal views on course issues.

IV. SAMPLE ACTIVITIES

ACTIVITY #5

TITLE: ACID RAIN

PURPOSE: To examine how acid rain is produced and the present and future environmental impact.

OBJECTIVE: Students should be able to:

1. Identify sources of acid rain.
2. Describe and write chemical reactions to explain acid rain formation.
3. Provide examples of the environmental impact of acid rain on humans, plants, animals and property.
4. Locate on U.S. maps the areas impacted by acid rain.
5. Predict future consequences of acid rain.
6. Suggest methods to control or prevent acid rainfall.

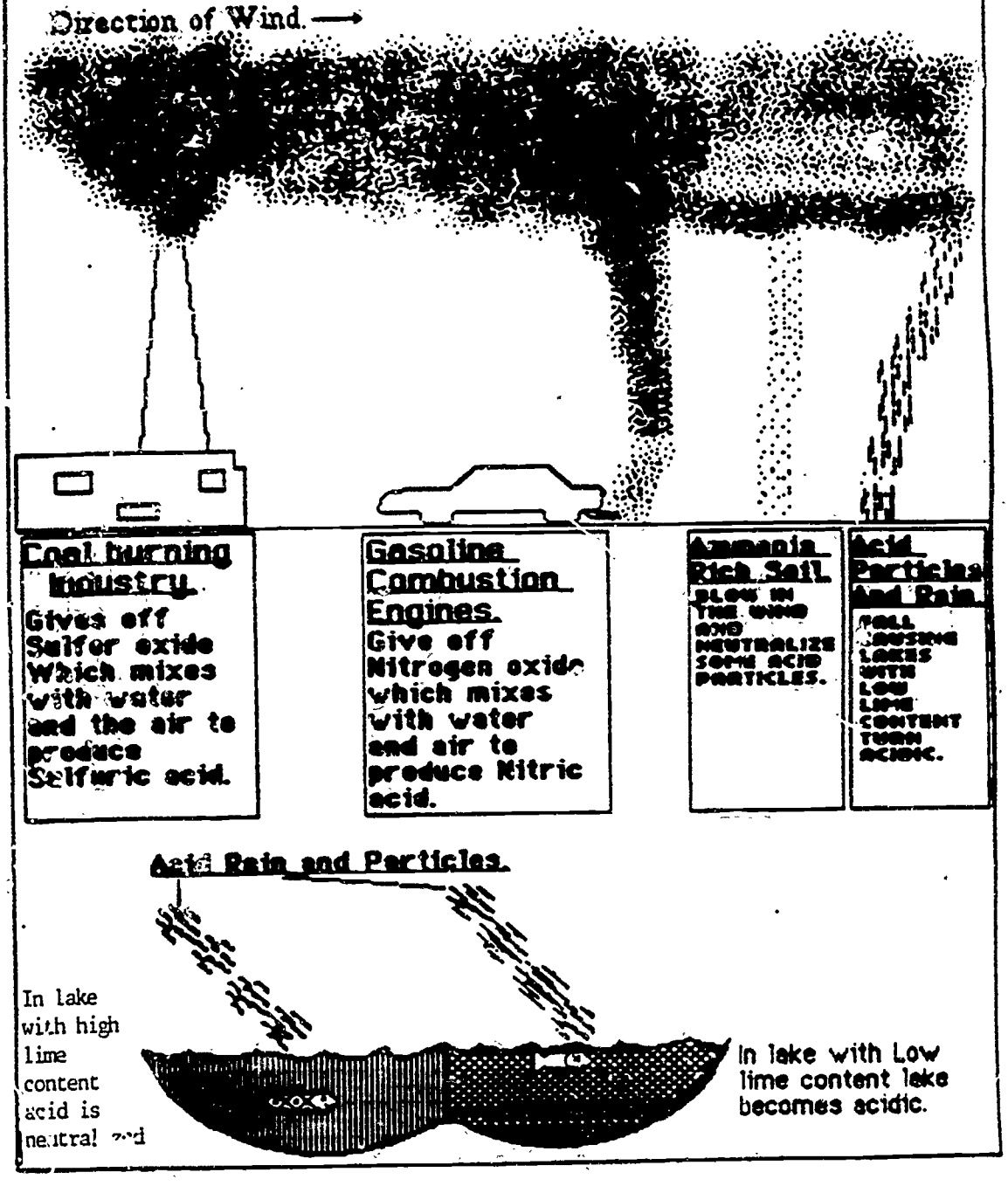
MATERIALS: Masters #IX-5 and #IX-6

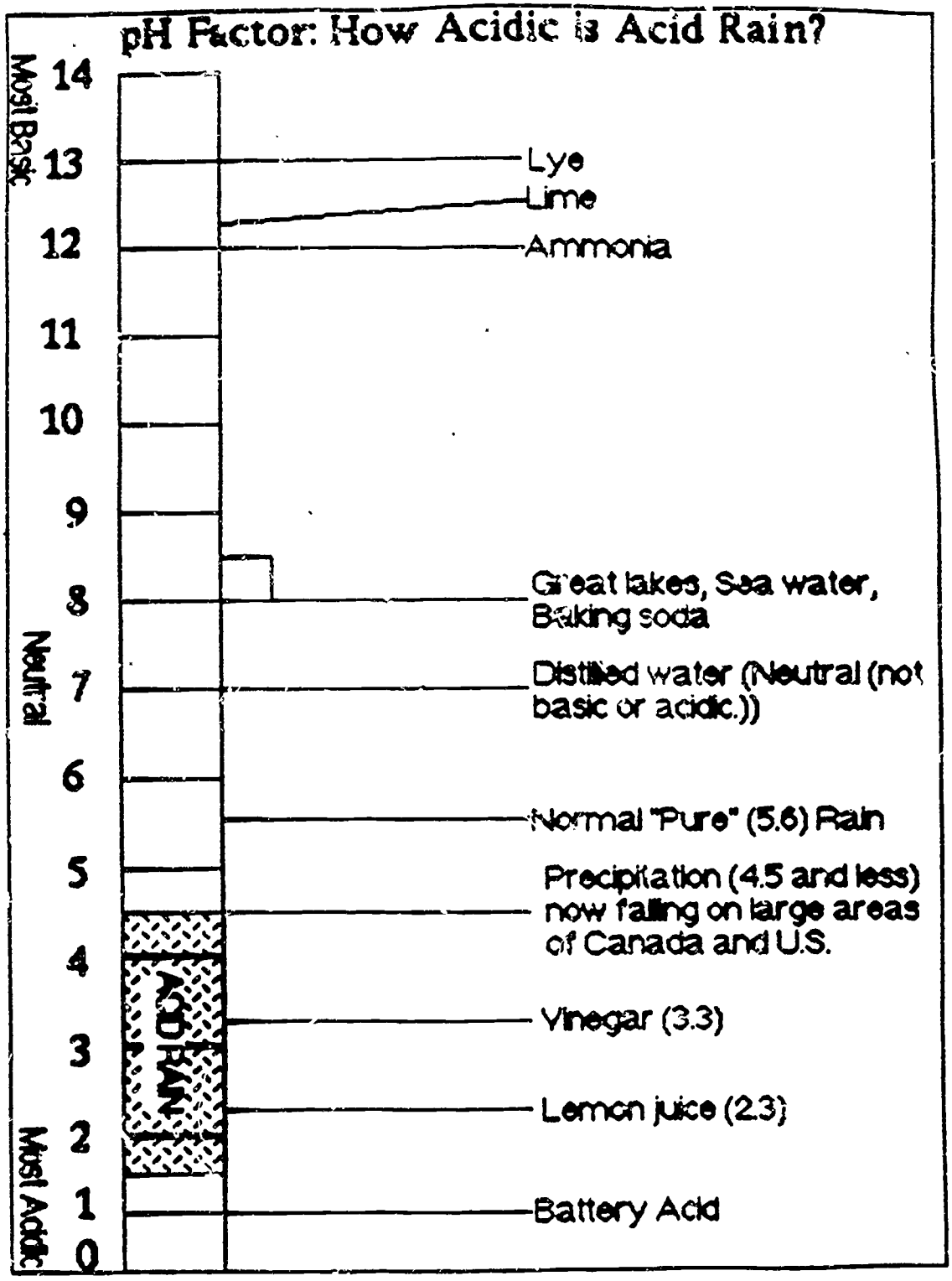
PROCEDURE:

1. Prepare transparencies and student copies of Masters #IX-5 and #IX-6.
2. Have students examine acid rain diagram and answer the following questions:
   a. Name the two gases which produce acid rain?
   b. What are two sources of each of the gases that produce acid rain?
   c. What are effects of acid rain on humans, plants, animals, and property? (Obtain information from students who have prepared research reports on acid rain during air pollution unit.)
   d. What are possible solutions to eliminate acid rain (e.g., industrial scrubbers, limit automotive use in certain areas, alternative energy sources)?

3. Have students examine map of eastern U.S. and diagram of PH scale and answer the following questions:
   a. Where are the major sources of sulfur-dioxide in the eastern U.S.?
   b. What areas are most sensitive to acid rainfall?
   c. What is measured by pH scale?
   d. What is the range of substances identified as basic (alkaline)?
   e. What is the range of substances identified as acidic?
   f. What is the pH of neutral substances?
   g. Identify two strong bases. pH?
   h. Identify two strong acids. pH?
   i. What is the pH range of acid rain?
   j. What is the pH of normal rainfall?

Formation Of Acid Rain.




pH Factor: How Acidic is Acid Rain?
Most Basic
Neutral
Most Acidic
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
ACID RAIN
Lye
Lime
Ammonia
Great lakes, Sea water, Baking soda
Distilled water (Neutral (not basic or acidic.))
Normal "Pure" (5.6) Rain
Precipitation (4.5 and less) now falling on large areas of Canada and U.S.
Vinegar (3.3)
Lemon juice (2.3)
Battery Acid

ACTIVITY #2

TITLE: U.S. ENERGY SOURCES

PURPOSE: To examine the reliance on various sources of energy in the U.S. from 1850 to the year 2000.

OBJECTIVES: Students should be able to:

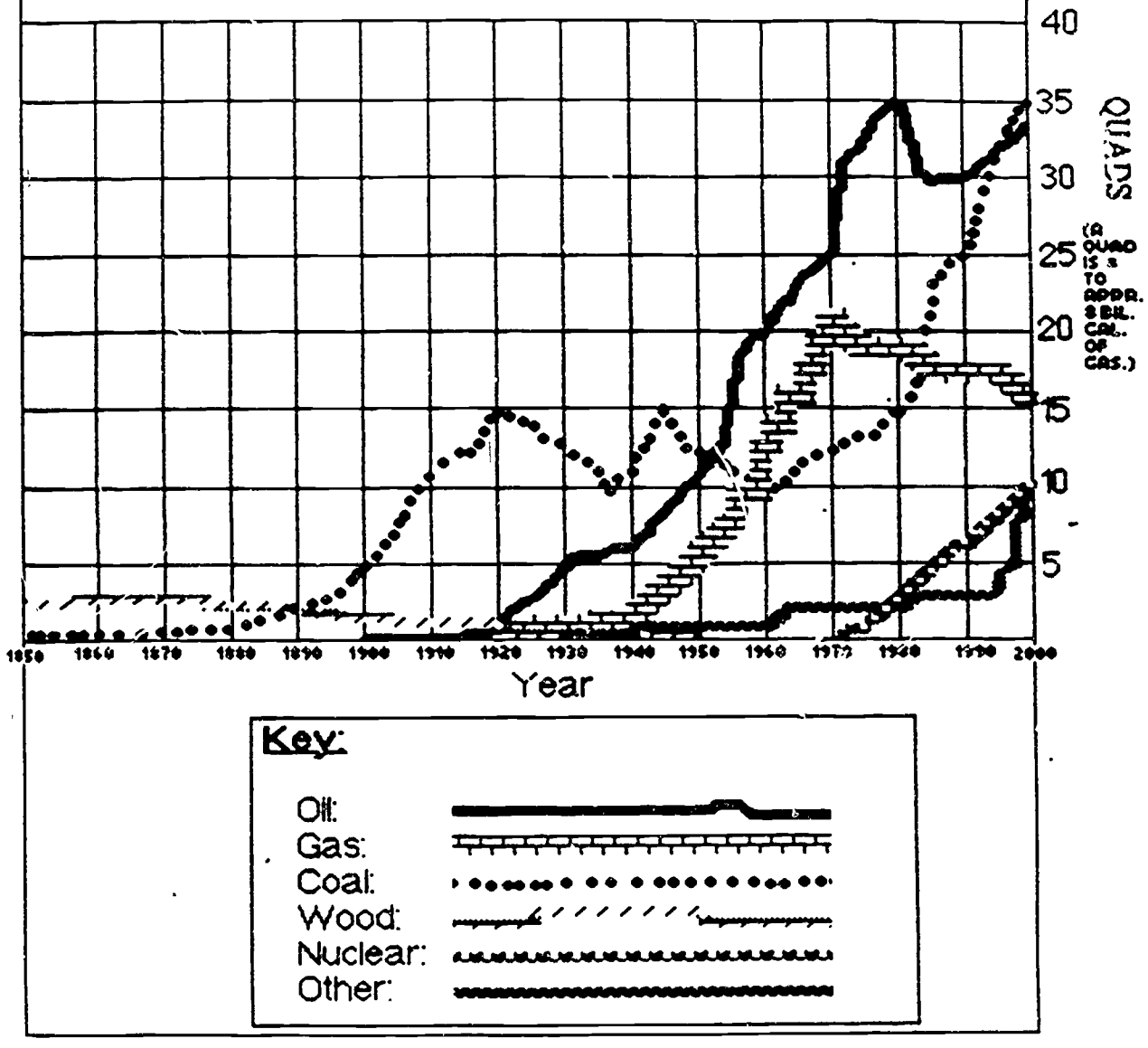
1. Identify the major U.S. energy resources.
2. Identify the principle energy resources used in 1850.
3. Identify the principle energy resources that will be in use by the year 2000.
4. State the changes predicted in our reliance on the various energy resources by the year 2000.
5. Analyze the impact on industry and society of a conversion from one energy resource to another resource.

MATERIALS: Master #XI-2

PROCEDURE:

1. Prepare a transparency and student copies of Master #XI-2.
2. Instruct students to examine the graph of energy sources from 1850 to the year 2000 and answer the following questions:
   a. What are the current energy sources available in the U.S.?
   b. What were the chief energy sources used in 1850?
   c. What were the chief energy sources used in 1900?
   d. What was the chief energy source used in 1945?
   e. What was the chief energy source used in 1980?
   f. By the year 2000, what two energy sources are expected to <u>increase</u> in useage? What two energy sources are expected to <u>decrease</u> in useage?
   g. What impact on industry and society will the increased use of coal and nuclear power as energy sources have?

The Way In Which U.S. Energy Sources Have Changed.



V. PROGRAM EVALUATION DESIGN AND RESULTS

Evaluation procedures were designed to measure both cognitive growth and affective change of students enrolled in Contemporary Science.

Mastery of course content as a measure of cognitive growth was assessed through the use of a Pre/Post Test consisting of 100 questions. Affective change was determined by student attitudinal changes on 17 selected issues addressed during the course. In addition, a student and parent evaluation form was utilized to provide feedback on course effectiveness.

PRE/POST TEST

A 100 question Pre/Post Test was designed to measure student knowledge of the following science areas: Branches of Science, Population, Intoxicants, Nuclear Energy, Astronomy, Space Exploration, Human Behavior, Air Pollution, Water Pollution, Noise Pollution, Energy Resources, Meteorology. The Pre Test was administered during the first class meeting and the Post Test at the last meeting. With use of a dependent t-test, analysis of Pre/Post Test scores indicated a Pre Test mean score of 36.53 (s.d.= 11.18, n = 83) and a Post Test mean score of 79.20 (s.d.= 14.80, n = 83). This result is statistically significant (t.0001 = -24.57). In addition, the net increase of + 42.67 points on the Post Test indicates a considerable growth in student knowledge about the topics examined in the course.

To assess the effect of this course as an intervention factor the Pre/Post Test was also administered to an Honors Physics class. These students showed a Pre Test mean score of 72.66 (s.d. = 11.42, n = 9) and a Post Test mean score of 75.77 (s.d. - 10.8, n = 9). No significant difference was demonstrated (t.158 = -1.54). A comparison of the post test scores indicates that the Contemporary Science students exhibited a more significant growth in knowledge. They performed as well as Honors Physics students on this evaluation instrument.

STUDENT ATTITUDE SURVEY OF ISSUES

A student attitude survey of science issues was administered to investigate attitudinal changes on 17 science related issues presented in

the course of study. A five point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree) was employed to indicate responses. Each issue had a set of three questions posed in the evaluation, consequently a value of fifteen (15) was possible for each.

Analysis indicated a small but statistically significant change in attitude on 11 of 17 issues examined through the course (See Data Analysis Chart). In addition, the data indicates a positive change in attitude on 16 of the 17 issues. Although small in magnitude, this change is educationally significant. This change in attitude toward science related issues is an important course goal and consequently is an encouraging outcome.

DATA ANALYSIS OF STUDENT ATTITUDE SURVEY

SCIENCE ISSUE	N	PRE TEST	POST TEST	CHANGE	t	SIG. LEVEL
SPACE	100	10.560	11.300	+0.740	3.36	.002 *
CAREERS	100	10.160	10.640	+0.480	1.68	.093
POLLUTION	100	9.880	10.440	+0.560	2.29	.023 *
TECHNOLOGY	100	9.550	10.190	+0.640	2.26	.024 *
FUTURE	100	10.960	11.610	+0.650	2.58	.011 *
ELECTRICITY	100	8.940	9.540	+0.600	2.52	.013 *
ENERGY	100	8.080	8.830	+0.750	2.97	.004 *
ECOLOGY	100	9.830	10.240	+0.410	1.76	.078
POL/BUS/GOV	100	10.540	11.360	+0.820	3.04	.003 *
POPULATION	100	10.540	11.360	+0.820	3.04	.003 *
ASTRONOMY	100	10.860	11.540	+0.680	3.17	.002 *
DRUGS	100	12.400	12.410	+0.010	0.03	-
SMOKING	100	9.020	9.370	+0.350	1.19	.235
CIVIL DEFENSE	100	6.250	6.380	+0.130	0.733	-
NUCLEAR TECH	100	9.030	9.740	+0.710	2.62	.010 *
METEOROLOGY	100	11.050	11.400	+0.350	1.37	.169
BEHAVIOR	100	11.510	12.410	+0.900	3.67	.001 *

NOTE - * Indicates statistically significant change in attitude

STUDENT COURSE EVALUATION

A course attitude survey was used to evaluate the various materials, techniques, and outcomes of the program as perceiver by the students. The areas evaluated and the student responses are as follows:

STUDY SKILLS

Responses indicate significant numbers (76%) of the students believed that their writing and library research skills were improved.

LEVEL OF PRESENTATION/DIFFICULTY

In an attempt to determine if the course instruction was presented at an appropriate level of difficulty, students were requested to respond to a series of five questions that addressed this area. The results suggest that most students (87%) felt that the degree of difficulty was appropriate and that they had sufficient academic background to meet the course proficiencies.

In addition, due to the heterogeneity of the course, students were asked if they had difficulty keeping up with other students. Eighty-seven percent (87%) of the students indicated that they were not at a disadvantage.

COURSE VALUE

The major goals of this instructional program were designed to promote the development of decision making skills and an understanding of the process of science.

The results of the student survey revealed that 93% of the students say they were able to evaluate the benefits and risks of key issues related to science and technology.

The development of positive attitudes toward science was a major program goal. Student responses indicated that 92% believed that the course increased scientific interest and promoted an understanding of the need for scientific research.

The students agreed that the course helped them to become more effective and informed citizens.

Ninety-eight percent (98%) of the students indicated that the course should be taken by other students.

STUDENT COMMENTS

The following student comments reflect attitudes toward the program:

- "I know how important it is to keep our environment clean and how the environment affects human life."
- "I can now make decisions about things that affect me based on the factual information in this class."
- "We learned about things from the present. Things in the paper corresponded to the class."
- "I learned how science was related to my history class because of the study of nuclear weapons."
- "I now know that I have to take a stand about ocean pollution. The ocean is too beautiful to ruin."
- "Learning about future events that are going to affect our generation is important."
- "This course gave me a better outlook on my school work."

- "This course widened your knowledge, giving you more of an opinion on decisions."

- "I liked the constant change of subjects. I was not bored with the class. I was always learning."

- "This course helped me to use my opinions in decision making."

PARENT COMMENTS

Through the use of surveys, parents were encouraged to provide feedback about their youngsters' involvement in this course. The following is a list of some comments that parents provided:

- "I think this course was excellent. Too often we stress the scientific subjects which are difficult for most students to relate to but are necessary as part of their education."

- "My daughter took an interest in local and current problems."

- "This course increased my daughter's interest in science and it gave her the ability to relate what she learned in school to her own environment."

- "The topics made my daughter think. She was not reading in some book about past events. She was dealing with the present and thinking about her future."

- "I saw more interest in science and related subjects."

- "I would hope that this course continues because it keeps the kids interested."

- "My son learned science in a different way than they do in other classes."

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